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Non-edible palm oil: Alternative to mineral based lubricant in metal forming process

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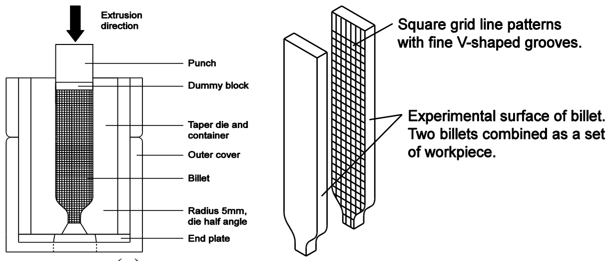
ABSTRACT – In this paper, the effect of non-edible oil in cold extrusion process were investigated by cold work forward plane strain extrusion experiments. It then was compared to existing metal forming lubricant additive free paraffinic mineral oil, VG95 and commercial extrusion oil. A pair of taper die and a symmetrical work piece (billet) was placed inside extrusion rig which acted as main experimental apparatus. The experimental result shows that nonedible oil has similar maximum extrusion load with mineral based lubricant and commercial extrusion oil.

1. INTRODUCTION

Vegetable oil is divided into two categories, edible and non-edible oil. Non-edible vegetable oils or also known as tree borne oil seeds are not suitable for human food due to the presence of some toxic components in the oils [1]. As mentioned by [2] and [3], liquid plant oils appear to be well fit for metal forming because of its stability and palatability. Besides that, plant is a renewable resource and environmental friendly [4], so that it can be easily decomposed. Furthermore, vegetable oils are biodegradable and non-toxic, unlike conventional mineral-based oils [5]. As a result, the cost of acquiring plant oil is much cheaper, compared to mineral and synthetic oil. Thus, the use of non-edible oil can help to overcome the issues of environmental pollution. Due to depletion issue and environmental problems from mineral based lubricants, evaluation of potential non-edible oils are carried out in order to investigate their suitability as an alternative lubricant in extrusion process, as well as other metal forming processes. Non-edible oil is chosen because it possesses some characteristics which make it suitable to be used as a lubricant in extrusion. It is also not involving food based market which related with edible oils. This present work hopefully, would help to promote the application of renewable natural resources as well as to protect the environment.

2. METHODOLOGY

Fig. 1 illustrates the experimental set-up of the plain strain extrusion apparatus, while Fig. 2 shows a schematic sketch of the billets used in the experiments. The billet material is pure aluminum (A1100). The main components are container wall, taper die, and work piece (billet). The taper die has a sharp edge with 5 mmm die half-angle. This plain extrusion apparatus was assembled and placed on the load cell to record the load extrusion (Y-axis) during each test. The displacement of ram stroke (X-axis) also was recorded by using the displacement sensor is attached to the holder of plain extrusion apparatus. Extrusion was stopped at a piston stroke of 35 mm, where the extrusion process is expected in steady state condition. After the experiment, the partially extruded billets were taken out from the plane strain extrusion apparatus and the combined billets were separated for the surface roughness measurement.



(a) (b)

Fig. 1 (a) Schematic of plane strain extrusion apparatus; (b) Schematic for billet used in the experimental works.

Lubricants. The tested lubricant from non-edible palm oil is RBD palm kernel. RBD is derived from Refined Bleached Deodorized, which means that oil has gone through a purifying process to dissipate the unnecessary fatty acid and odour. It was compared to existing metal forming lubricant, commercial extrusion oil and additive free paraffinic mineral oil, VG95 in order to find out whether there is any significant mcorrelation between each tested lubricants. One drop of lubricant (approximately 15 mg) was applied on the experimental surface of taper die before the experiment. The initial lubricant amount was predicted to create full film lubrication regime at the early stage of extrusion process.

3. RESULTS AND DISCUSSION

Extrusion Load. The extrusion load reached a constant level during the process and the extrusion process becomes a steady state condition at a piston stroke 15 mm onwards. The maximum extrusion load

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for RBD palm kernel, commercial extrusion oil and PMO VG95 are 77.80 kN, 80.54 kN and 60.67 kN respectively.

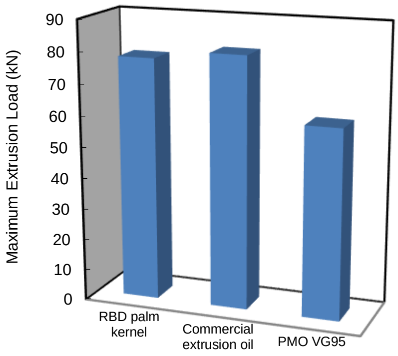

Fig. 3 Maximum extrusion load.

As plotted by bar graph in Fig. 3, clearly show that the viscosity of lubricant can leads to its ability in reducing friction. PMO VG95 become a lowest extrusion load among the others, and yet the highest viscous lubricant during experimental temperature. Due to that, it will result less friction and less extrusion load during extrusion process. A lesser metal-to-metal contact between billet and taper die resulting less friction and less extrusion load. [6] said that a lubricant is suitable to be applied on extrusion process if the lubricant used can minimize the extrusion load to a reasonable range. RBD palm kernel and commercial extrusion oil seems to have more contact and it proved that when more metal-to-metal contact occurs, the process need more energy to shear the material and make the extrusion load becomes higher [7,8].

Surface Roughness and Wear Observation. The experimental surface was defined as the surface of billet which was in contact with each other with taper die and container during the extrusion process. The measure direction is perpendicular to the extrusion direction. The distribution of arithmetic mean surface roughness, Ra in product area is shown in Fig. 4. The analysis area for the billets is same as tested for wear observation in Fig. 5.
All tested lubricants tend to stay at the surface of contact area due to their high concentrated physical attributes. The surface roughness values were slightly lower from the beginning of the process towards the end. For less viscous lubricant, more metal-to-metal contact between sliding surface occurs, resulting higher friction and wear [9]. Nevertheless, CCD image shows that no severe wear occurred among all tested lubricants.

4. CONCLUSIONS

A type of non-edible palm oil, RBD palm kernel was tested as lubricant using plane strain extrusion apparatus. Non-edible oil has similar maximum extrusion load with commercial extrusion oil with low surface roughness at product area, and yet no severe wear occurred. To be conclude, RBD palm kernel was evidenced can be considered as one of alternative to metal forming lubricant in the future.

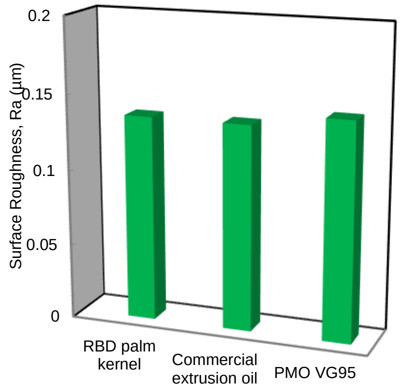

Fig. 4 Surface Roughness at product area.

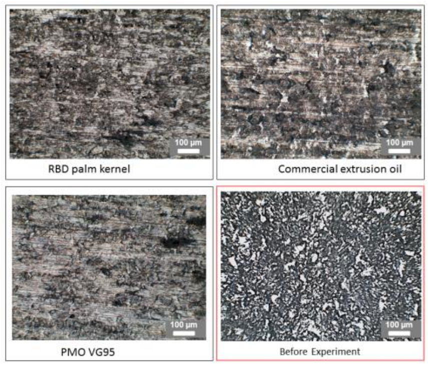

Fig. 5 Wear observation at product area.

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